DOCUMENT RESUME

ED 043 225 EM 008 371

AUTHOR Meyer, John K.
TITLE The Relative Efficiency of Pretesting and Two Types of Programed Instruction for Solving Maneuvering Board Problems.
INSTITUTION Naval Personnel Research Activity, San Diego, Calif.
SPONS AGENCY Office of the Chief of Naval Personnel, Washington, D.C.
REPORT NO SRR-69-20
PUB DATE Mar 69
NOTE 21p.

EDRS PRICE EDRS Price MF-$0.25 HC-$1.15
DESCRIPTORS Advanced Placement, *Effective Teaching, Pretesting, Problem Solving, *Programed Instruction, *Programed Texts
IDENTIFIERS CIC, *Combat Information Center, Maneuvering Board Problems

ABSTRACT

Study time for a large frame and a small frame type of program explanation in maneuvering solutions was compared using two equated, pretested groups of enlisted men in a basic Combat Information Center (CIC) techniques course and two equated groups assigned to basic electricity and electronics training. It was found that, by using pretesting, as many as 60 percent of the CIC techniques students could save study time by entering the learning program at an advanced level, and that as much of 42 percent of study time (e.g., over two and one-half hours in the first six of the explanation chatpers alone) could be saved by using a few large rather than many small frames. (Author)

U. S. NAVAL PERSONNEL RESEARCH ACTIVITY

SAN DIEGO, CALIFORNIA 92152

RESEARCH REPORT SRR 69-20 MARCH 1969

THE RELATIVE EFFICIENCY OF PRETESTING AND TWO TYPES OF PROGRAMMED INSTRUCTION FOR SOLVING MANEUVERING BOARD PROBLEMS

John K. Meyer

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THE RELATIVE EFFICIENCY OF PRETESTING AND TWO TYPES OF PROGRAMMED INSTRUCTION FOR SOLVING MANEUVERING BOARD PROBLEMS

by

John K. Meyer

March 1969

PF39.522.004.01.07
Research Report SRR 69-20

Submitted by

Edward A. Rundquist, Ph. D., Director
Motivation and Individual Differences Research Department

Approved by

E. I. Jones, Ph. D., Director, Navy Training Research Laboratory
E. E. Dudek, Ph.D., Technical Director
G. W. Watson, Commander, USN
Commanding Officer

Navy Training Research Laboratory
Naval Personnel Research Activity
San Diego, California 92152

SUMMARY AND CONCLUSIONS

Problem

The original intent of this study was to compare large frame with small frame programmed instruction (PI) in maneuvering board problem solving for Navy personnel. This purpose was enlarged to include a comparison of the effects of pretesting relative to types of PI, when those to be trained varied in experience in solving maneuvering problems.

Background and Requirements

PI has been consistently found useful in reducing learning time. Written learning programs for complex subjects tend to be bulky and unwieldy. This limits the extent of their use. Programming in larger frames can reduce this bulk. If PI with large frames meets the same criteria of learning as PI with small frames, the reduction in the bulk of the program will make PI easier to use. If, in addition, the reduction in PI length permits completing the large frame program more rapidly, real savings in time of instruction can result. Additional training time savings can result from use of pretests to determine where individuals, differing in experience, should enter a learning program. The student bodies of the Basic CIC Techniques for Enlisted Personnel course at the Fleet Anti-Air Warfare Training Center, San Diego (FAAWTRACENSD) do vary widely in training and experience with maneuvering board problem solving. There is, therefore, a requirement for greater individualization of maneuvering board instruction in this course.

Approach

The programmed texts and pretests developed for this study are based on the learning objectives concerning maneuvering board problems currently stated for enlisted personnel in their courses at FAAWTRACENSD. Two learning programs were developed from a Navy programmed maneuvering board text. These were first used in an experiment with college students, then further modified for use in this experiment. Achievement and time measures for completing the two texts were compared for students in the FAAWTRACENSD course, Basic CIC Techiques for Enlisted Personnel, and for seamen awaiting assignment at the Naval Training Center (NTC), San Diego. Pretests could be used only for the former, the latter having had no prior experience in solving maneuvering problems.

Findings

Results from the studies with enlisted men confirm those from studies with college students. PI with large frames, relative to PI with small frames, saves considerable time in learning to solve maneuvering problems without loss in final achievement. By far the more practical

finding is the gain from use of pretests as an aid to individualizing instruction. Time saved by use of pretests was several times that saved by use of large frame PI.

Conclusions

1. Use of pretests as a basis for individualizing instruction has not only potential for tremendous gains in efficiency of instruction in absolute terms, but also relative to the gains that can be expected from change in type of PI used.

2. The large frame programmed maneuvering board text produced equal learning in a shorter time than did the small frame text for students entering the PI at a level determined by the entry capability of each student. The saving in time indicates the promise of the approach suggested by Pressey (1963, 1964).

Recommendations

1. Pretests, being more important to saving instructional and student time than particular methods of instruction, should be uniformly used for courses whose entering students have varied experience with the instructional content. (Page 5)

2. If PI instruction, in maneuvering board learning at least, is to be employed, large rather than small frame PI should be used unless great difficulty of learning is anticipated. (Pages 6-8)

3. The objectives of the Basic CIC Techniques for Enlisted Personnel course need reexamining in relation to the length of the course. (Page 8)

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THE RELATIVE EFFICIENCY OF PRETESTING AND TWO TYPES OF PROGRAMMED INSTRUCTION FOR SOLVING MANEUVERING BOARD PROBLEMS

A. Background and Purpose

In most programmed instruction (PI) courses, the student responds to a brief presentation such as a paragraph or problem statement by writing an answer to a question or working an exercise. The presentation plus the response is the definition of a frame used in this study. The program tells the student whether he is right or not, and if not, guides him to a correct response.

Individualized small frame PI may permit personnel at a relatively low aptitude level to learn difficult topics, but at the expense of increased study time (Ford & Meyer, 1966). Research on instruction at the college level (Pressey, 1963, 1964; Pressey & Kinzer, 1964) suggests that PI can improve learning on subtopics of special difficulty but may be less efficient if employed as a replacement for a full presentation of text. Pressey found that if only a small part of a text is programmed, less study time is required for an equivalent achievement. Meyer (1968) found that large frame maneuvering board instruction is more efficient for college students than small frame and does not involve a loss of achievement. Two research studies on PI, one by Senter, Abma, Johnson, & Morgan (1966) and one by Gagne' & Brown (1961) emphasize a finding which appears to be consistent with many studies: PI may increase the over-all level of achievement by helping the student employ or strengthen habits of active questioning and responding.

The present study started with the purpose of determining whether the advantages of large frame PI found for college students in learning to solve maneuvering board problems would be found for Navy enlisted personnel. A companion study, started earlier with Navy officers entering the Combat Information Center Watch Officer course (CICWO) at FAAWTRACENSD, illustrated the tremendous importance of adapting instruction to individual differences in experience for saving training time. The comparison of PI type for CICWO officers could not be accomplished because of the large number of students that could meet end-of-course standards in solving maneuvering problems when they entered the course. Use of pretests to determine point of entry to the PI programs revealed that approximately four-fifths of 185 officers entering the course could meet these standards. This experience led to the expansion of the purpose of the study with enlisted men to include a comparison of time saved by pretesting with time saved by PI type.

B. Developing the Instructional Treatments

The development of the two types of PI (large frame and small frame[1]) has been described in an earlier report (Meyer, 1968).

Changes in the PI for the present study were based on the performance of college students and included instruction on (a) determining how to convert bearings given as reciprocal or relative bearings into true bearings;

[1] Termed "condensed" and "small step" in the previous study.

and (b) determining how to plot relative movement speed vector when the solution requires finding a course or speed for student's own ship based partly on the movement of another ship. Changes were also made in chapter tests and in cross-references specifying review of particular topics. The contents of both large and small frame programs used in this study were equivalent in all respects. The only difference was frame size. The small-size frame program employed up to 10 times as many explanation frames as the large-size frame program. Practice chapters, distinguished from explanation chapters, were identical.

To take into account previous maneuvering board training and experience, a series of pretests or advanced standing tests were developed (Figure 1). These tests were constructed by paralleling the practice chapter self-tests in a manner to make them formally equivalent, e.g., changing the maneuvering problem by some number of degrees while keeping the situation the same. Performance on the pretests showed the student where to enter the program.

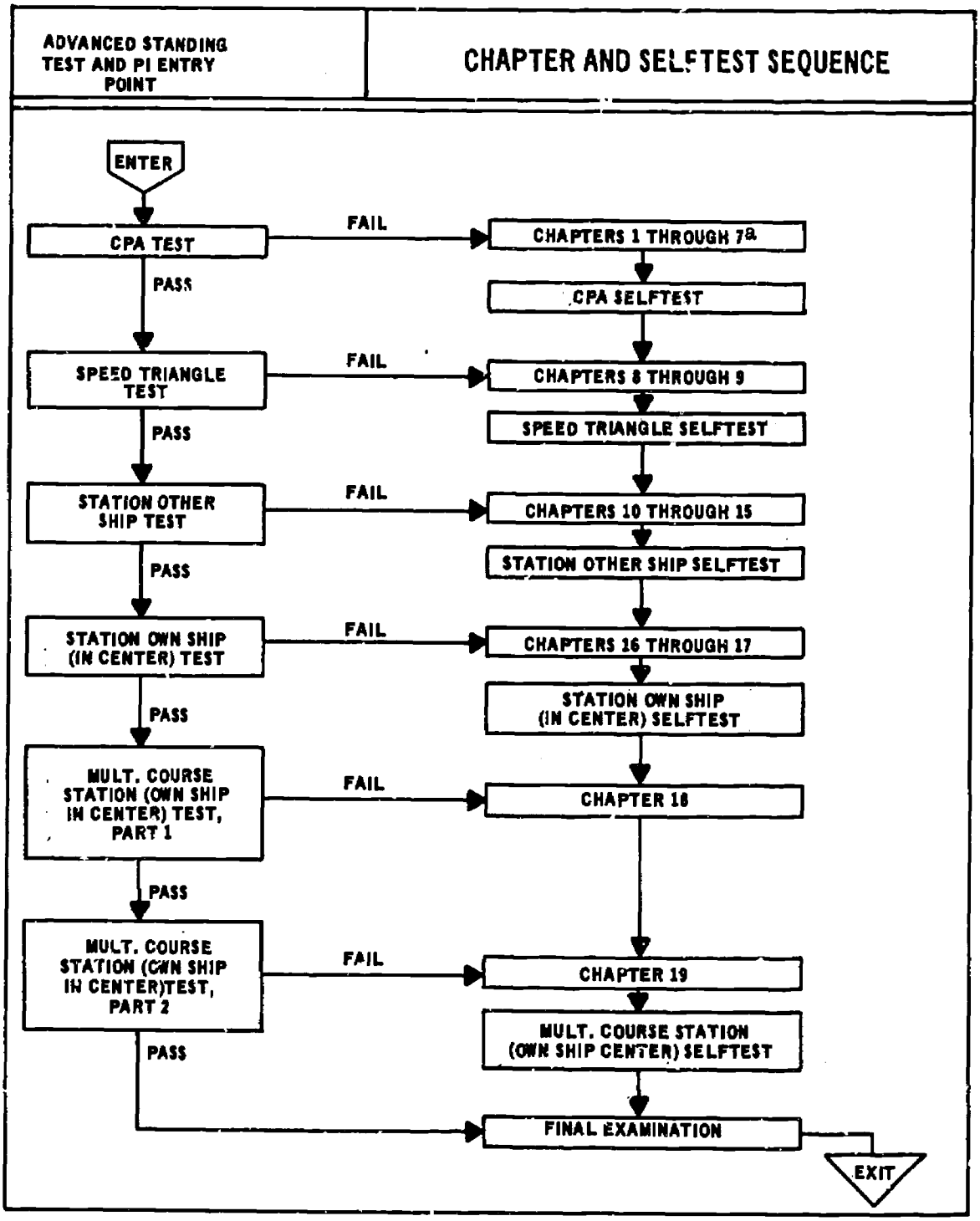
C. Subjects

Pretest data were available for 263 enlisted men entering the Basic CIC Techniques Course for Enlisted Personnel at FAAWTRACENSD. Only 81 cases, however, were available for comparing the efficiency of the large and small frame types of PI. This heavy loss of subjects was the result of a number of reasons, including the inability of the school to give the correct final examination, and to provide enough time for the trainee to complete both the PI and the final examination. Attrition from insufficient study time was heaviest among those students who entered the learning program early. Those assigned to the PI that normally takes the longer time, the small frame PI, were the more influenced by this source of attrition, and this, in turn, reduced the expected differences in study time between the two PI types. Because of the loss of subjects, a second study was conducted to verify the comparison of efficiency of the types of PI.

D. Procedure

1. Sequence of Learning

School personnel were instructed to assign students to PI type in a random manner. The student began with the earliest pretest, passed, and proceeded to the next pretest, or failed and began study at the beginning of the PI. A student failing an advanced pretest was directed to enter the PI at a point immediately following the chapter (Table 1) corresponding to the most difficult pretest he had passed. Each student entering the learning program was told to begin the PI by reading the introduction, and to proceed to the chapter specified by the highest test he had passed. Students were directed to follow the instructions in the PI and work through the PI from the point of entry without exchanging progress information or instructional information with other students. Students failing to complete the PI in the class time allowed were encouraged to work extra hours. Instructor personnel were asked to refrain from introducing extraneous instruction.



[a]Chapter titles are listed in Table 1, page 4.

Fig. 1. Tests of advanced standing and student sequence in maneuvering board PI chapters.

TABLE 1

Maneuvering Board PI Chapter Groups (See Figure 1)

Chapters 1-7: Preliminary Tool Topics and CPA

1. The Polar Coordinate Plot
2. Conversion Scales
3. The Nomogram
4. Developing the Relative Plot
5. Determining the Closest Point of Approach } Explanation
6. Determining the Closest Point of Approach (Practice)
7. Passing Ahead or Astern (Explanation)[1]

Chapters 8-9: The Speed Triangle

8. The Speed Triangle (Explanation)
9. The Speed Triangle (Practice)

Chapters 10-15: New CPA, Tool Topics, and Station Other Ship

10. Determining New CPA After a Course or Speed Change (Explanation)
11. Determining New CPA After a Course or Speed Change (Practice)[2]
12. Relative Bearings (Explanation and Practice)
13. The Three-Minute Rule (Explanation)
14. Station Taking, Determining Required Course and/or Speed for Maneuvering Ship (Own Ship as Reference Ship) (Explanation)
15. Station Taking, Determining Required Course and/or Speed for Maneuvering Ship (Own Ship as Reference Ship) (Practice)

Chapters 16-17: Station Own Ship (Centered on Maneuvering Board)

16. Station Taking, Determining Required Course and/or Speed for Own Ship as Reference Ship (Explanation)
17. Station Taking, Determining Required Course and/or Speed for Own Ship as Reference Ship (Practice)

Chapters 18-19: Multiple Course Stationing of Own Ship (Centered on Maneuvering Board).

18. Station Taking, Determining Multiple Courses and/or Speeds for Own Ship as Reference Ship (Specified Minimum Passing Distance) (Explanation)
19. Station Taking, Determining Multiple Courses and/or Speeds for Own Ship as Reference Ship (Specified Minimum Passing Distance) (Practice)

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[1] Because the Passing Ahead or Astern chapter was remedial for the CPA practice chapter and could be bypassed, the CPA test was placed after Passing Ahead or Astern rather than after the CPA chapter.

[2] No test of advanced standing was employed for the New CPA chapter because that topic is so similar to ordinary CPA.

The PI itself included instructions to conduct review based on specific requirement or failure, to avoid reading ahead, and to avoid reading any frame lead except the one specified by the student's own answer to each exercise.

2. Analysis

Because of the heavy loss of CIC techniques subjects, comparisons were limited to the simplest. Findings concerning the relative advantages of type of PI were regarded as tentative and were checked in a second study, also reported herein.

E. Results and Discussion

1. Pretesting and Elimination of Unnecessary Training (CIC Techniques Subjects)

The point of entrance to the learning program for the 263 enlisted men in successive classes of the course, Basic CIC Techniques for Enlisted Personnel, are given in Table 2. The data provide an obvious and forceful demonstration of the potential for improving efficiency of Navy instruction by pretesting.

TABLE 2

Number and Percent Entering Each Explanation Chapter of the Program

Chapter	Number	Percent
1	98	37
8	42	16
10	12	5
16	48	18
18	19	7
19	12	5
Final Exam	32	12
TOTAL	263	100

Less than 40 percent of the students required the complete program. Better than 10 percent needed scarcely any instruction. They were ready, or nearly ready, to try the final examination the day they entered the course.

Similarly, about four-fifths of the students entering the CIC Watch Officer Course were ready to take the final course examination on entry. It is clear that individualizing to eliminate the instruction of those who do not need it will have a large impact on course efficiency. As will

be seen in a moment, the gain in efficiency of training from this source is very large, relative to that possible from changing PI type.

2. The Consequences of Frame Type

The final examination scores on the 81 whose data were accurate and complete are presented by treatment in Table 3. While there is a mean difference in favor of the large frame treatment, it is not statistically significant. Accordingly, performance from the two types of PI can be considered equivalent.

TABLE 3

Final Examination Score Means and Standard Deviations by Treatment

Type of Programmed Instruction	
Small Frame	Large Frame
M 62.6	M 66.5
σ 12.8	σ 10.9
N 25	N 56

a. The CIC Techniques Students. Variations in the size of explanation frames may also influence the efficiency of study time regardless of prior qualification and pretesting. In Table 4, the small N's limit the statistical analysis. It can be seen that all the differences are in favor of the large frame groups, although only one is statistically significant at the five percent level. The consistency of the differences strongly suggests that large frame PI is more efficient. The benefits from enlarged frame size are greatest for those students who begin at the beginning, and who, consequently, are exposed to the largest concentration of explanation chapters (Table 1 and Figure 1). Hence the potential saving of study time from the use of large frames is undoubtedly underestimated.

TABLE 4

Explanation Chapter Study Times (Minutes) by Type of Explanation Frame and Entry Chapter

Chapter	Type of PI Explanation Frame		Difference
	Large	Small	
1	M 456 N 14	M 500 N 8	44[a]
8	M 316 N 19	M 411 N 2	95[b]
16	M 146 N 17	M 152 N 9	6[a]
18	M 55 N 6	M 83 N 6	28[c]

[a]Difference not significant.

[b]N too small for computation.

[c]Difference significant at .05 level.

b. The NTC Subjects. To recheck the conclusion that the large frame type of explanation may indeed contribute a saving of study time, a secondary set of data was obtained from 34 seamen awaiting assignment at the NTC, San Diego. Since none of these students had been exposed to maneuvering board operations, no subject matter pretests could be given. All began the PI at the beginning; hence, all had a maximum exposure to the initial five explanation chapters. To make sure that final examination scores would be available in the event that time was not sufficient for the program, the final examination problems for each part of the course were administered right after the self-test for that part (see Figure 1). (No final examination problems correspond to the "Station Other Ship" self-test.)

The sample for comparing frame type was limited to those students who completed the CPA and Speed Triangle parts of the PI (and the counterpart final examination segments) in the three available days of working time, and whose time records were complete. This sample included 17 large and 17 small frame subjects. The explanation chapter study data for comparing large and small frames, accordingly, were limited to chapters 1 through 5 and chapter 8 (Table 1); the first six of eleven explanation chapters in the PI. In turn, the achievement and study time means for the NTC students (Table 5) are not comparable with those for the CIC techniques students (Tables 3 and 4).

Comparisons resulting from the statistical analysis of the NTC students are presented in Table 5. Explanation study time saved by the large type of frame was over two and a half hours, with a high degree of statistical as well as practical significance. All other differences of both achievement and aptitude were small, and none approached statistical significance.

TABLE 5

Learning Data for Explanation Chapters 1-5 and 8 by Type of Explanation Frame for Basic Electricity and Electronics Trainees

Type of Data	Type of PI Explanation Frame		Difference
	Large	Small	(Small Frame Minus Large)
Criterion			
Achievement[a]	M 29.40 σ 6.36	M 30.11 σ 4.40	0.71[b]
Time (Minutes)	M 205.65 σ 55.37	M 357.68 σ 53.34	152.03[c]
Aptitude			
GCT	M 65.27 σ 5.05	M 62.74 σ 5.71	-2.53[b]
ARI	M 62.62 σ 4.96	M 60.68 σ 5.02	-1.94[b]
Sample Size	17	17	---

[a]Sum of CPA and Speed Triangle final examination scores.

[b]Not statistically significant.

[c]Highly significant statistically.

3. Course Objectives

An incidental finding concerns the objectives of the Basic CIC Techniques Course for Enlisted Personnel at FAAWTRACENSD. The difficulty experienced by these students in completing the program within the time allowed points to the need for reexamining the objectives in relation to the length of the course.

F. Conclusions and Recommendations

In this research study, it was found that a majority of students in the FAAWTRACENSD ccurse, Basic CIC Techniques for Enlisted Personnel, and in the CIC Watch Officer course were capable of entering a maneuvering board learning program at an advanced level, given the availability of an adequate pretesting arrangement. Very large savings of study time were found. Accordingly, the first recommendation is that pretests not only be employed in all maneuvering board instruction of experienced personnel, but that use of pretests be investigated for all Navy courses involving instruction of students varying widely in pertinent skill or knowledge.

A second finding, consistent with previous work of Pressey (1963) and Pressey (1964), was that the employment of a few large rather than many small linear frames in the explanation chapters of the learning program shortened the study time for students to reach an acceptable standard of solving maneuvering problems. Accordingly, the second recommendation is that explanations in programmed maneuvering board instruction employ a few large rather than many small frames unless extreme difficulty of learning is anticipated.

A third finding was that in the Basic CIC Techniques for Enlisted Personnel course, those students who could enter the maneuvering board learning program only at the beginning, and who most needed the individual benefit of a slow pace did not have enough time to finish the learning program. A third recommendation, therefore, is that the objectives of instruction in the basic CIC techniques course be reevaluated and study time be allocated accordingly.

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1. ORIGINATING ACTIVITY (Corporate author)	2a. REPORT SECURITY CLASSIFICATION
Naval Personnel Research Activity San Diego, California 92152	UNCLASSIFIED
	2b. GROUP N/A

3. REPORT TITLE

THE RELATIVE EFFICIENCY OF PRETESTING AND TWO TYPES OF PROGRAMMED INSTRUCTION FOR SOLVING MANEUVERING BOARD PROBLEMS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final

5. AUTHOR(S) (First name, middle initial, last name)

John K. Meyer

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
March 1969	19	4

8a. CONTRACT OR GRANT NO	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO PF39.522.004.01.07	SRR 69-20
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
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DD FORM 1 NOV 65 1473 (PAGE 1)

S/N 0101-807-6801

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14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Programmed Instruction Maneuvering Board Explanation Pretesting Advanced Entry Efficiency Frames-Size Problem Solving						